

Effectiveness Of Behavioral Interventions In Age-related Cognitive Decline: A Meta-analysis.

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Background: There is increasing interest at the clinical level and at the policy level in the use of behavioral interventions - specifically Cognitive Training (CT), Physical Exercise (PE), and Nutrition (NU) to improve brain health and cognitive function in older adults.

Problem: Direct comparisons of the relative efficacy of various classes of behavioral interventions are challenging because meta-analyses typically focus on a single type (CT, PE, or NU) and use different inclusion criteria and analytical methods. Clinicians and policy-makers lack comprehensive comparable data to recommend interventions to patients and to define overall clinical guidelines.

Objective: Develop an open-source database of randomized controlled trials of CT, PE, and NU interventions with a common set of inclusion criteria and evaluate the relative efficacy of various classes of interventions with meta-analysis.

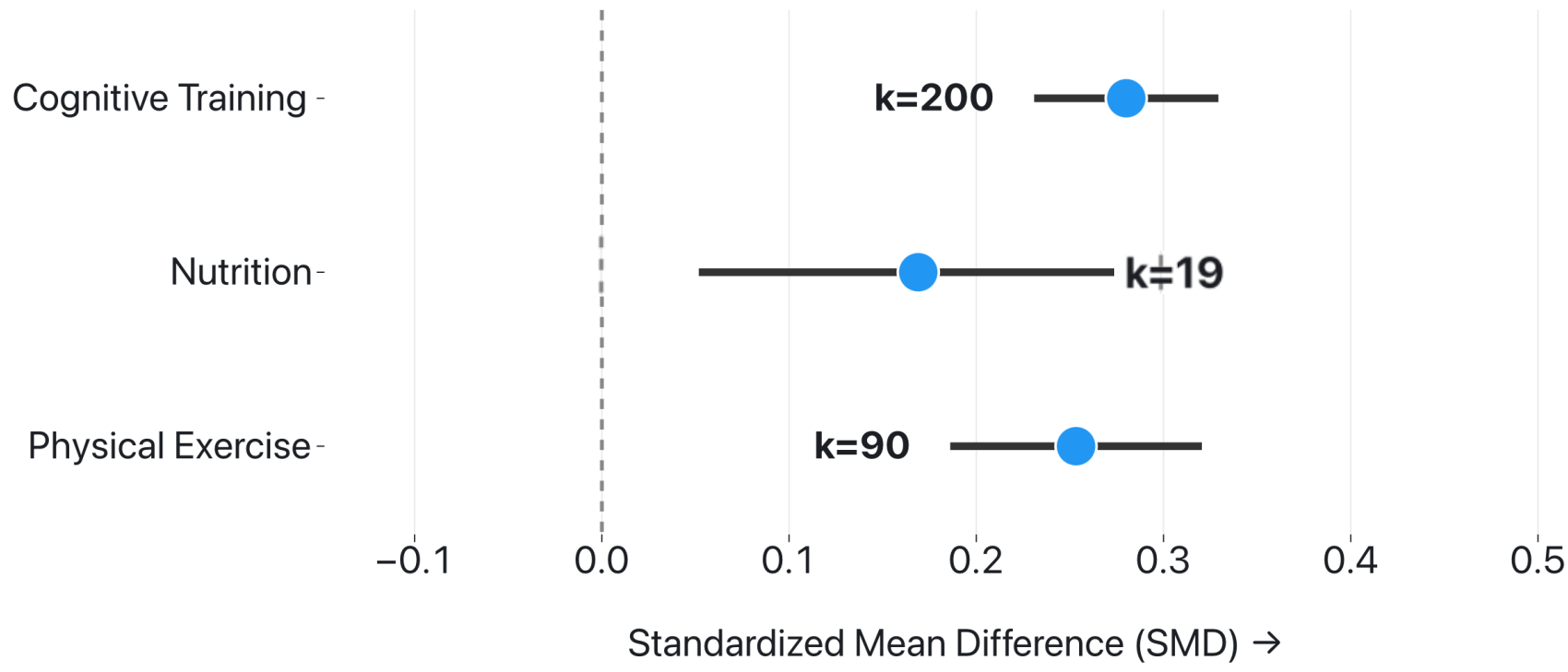
Search Strategy: We reviewed the top 50 meta-analyses for each intervention class. The search identified 853 publications, of which 606 were excluded. 247 publications comprising 309 clinical trials were included in the analysis. A detailed description of the search strategy is provided on the accompanying website.



ANALYSIS BY INTERVENTION CLASSES

SUBGROUP CATEGORY	STUDIES (K)	POOLED SMD	95% CI	HETEROGENEITY (I ²)
Cognitive Training	200	0.28	[0.23, 0.33]	86.8%
Nutrition	19	0.17	[0.05, 0.29]	87.0%
Physical Exercise	90	0.25	[0.19, 0.32]	83.6%

POOLED EFFECT SIZES (FOREST PLOT)



All three classes show statistically significant benefits vs control, with CT showing the numerically largest benefit and the NU benefit having the most uncertain range, due to the limited number of studies.

THE INFLUENCE OF CONTROL CLASS ON INTERVENTION EFFICACY

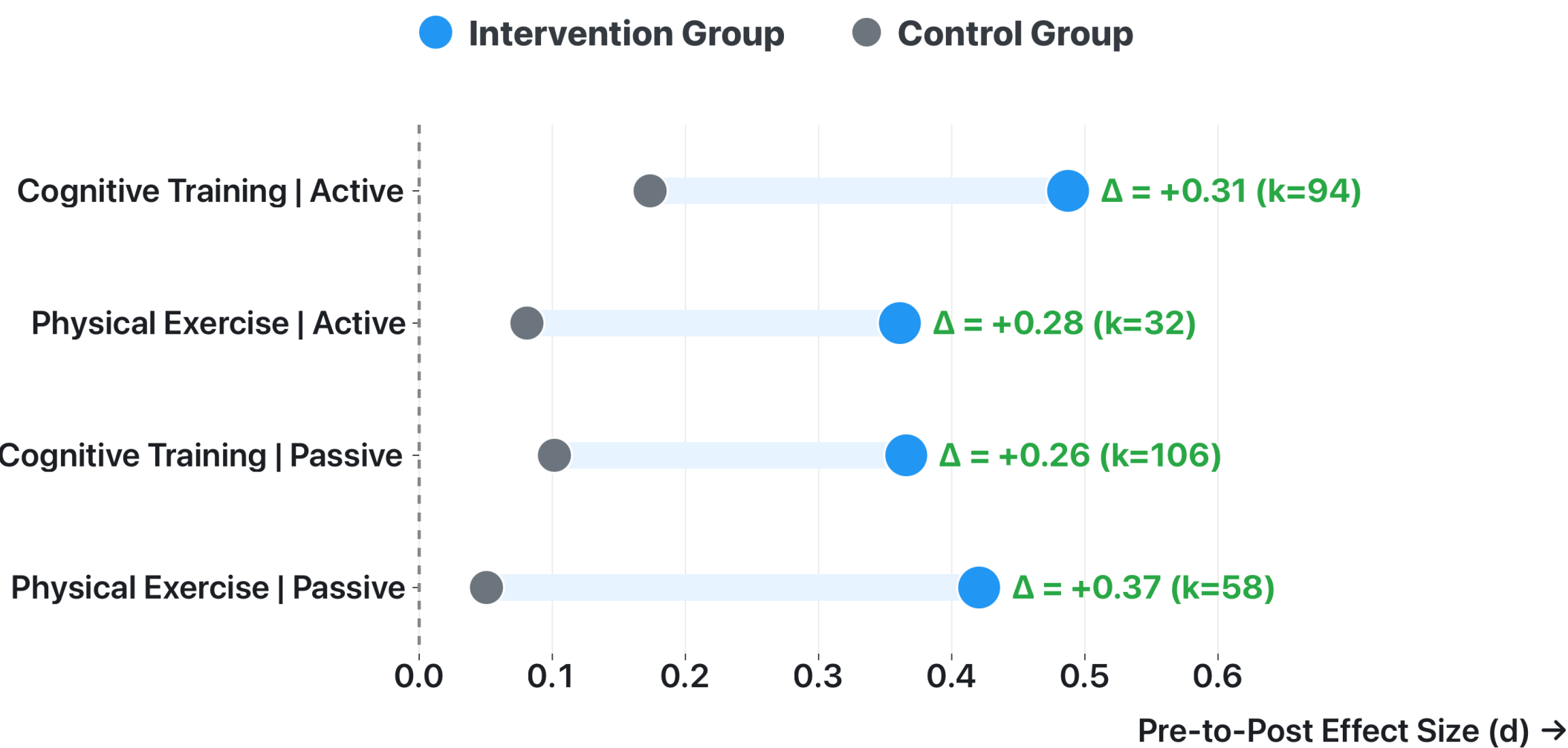
Cognitive Training: Net effect sizes are *numerically higher* in trials with active controls (0.33) than passive controls (0.23).

Physical Exercise: Net effect sizes are *significantly lower* ($p=0.024$) in trials with active controls (0.14) than passive controls (0.29).

Nutrition: Net effect sizes are similar in trials with active (0.18) and passive (0.14) controls

NET ADVANTAGE ANALYSIS

Comparing standardized mean difference (SMD) improvements by Time (Pre to Post) between Intervention and Control groups.



In CT, active controls showed larger pre-post effect sizes in both intervention and control groups. In PE, active controls showed larger effects in the control group, whereas passive controls showed larger effects in the intervention group.

EFFICACY BY CLINICAL POPULATION: HEALTHY AGING VS. MCI

Global Effect: All interventions were effective for both groups but yielded numerically higher gains in MCI population (0.31) compared to Healthy Aging (0.26).

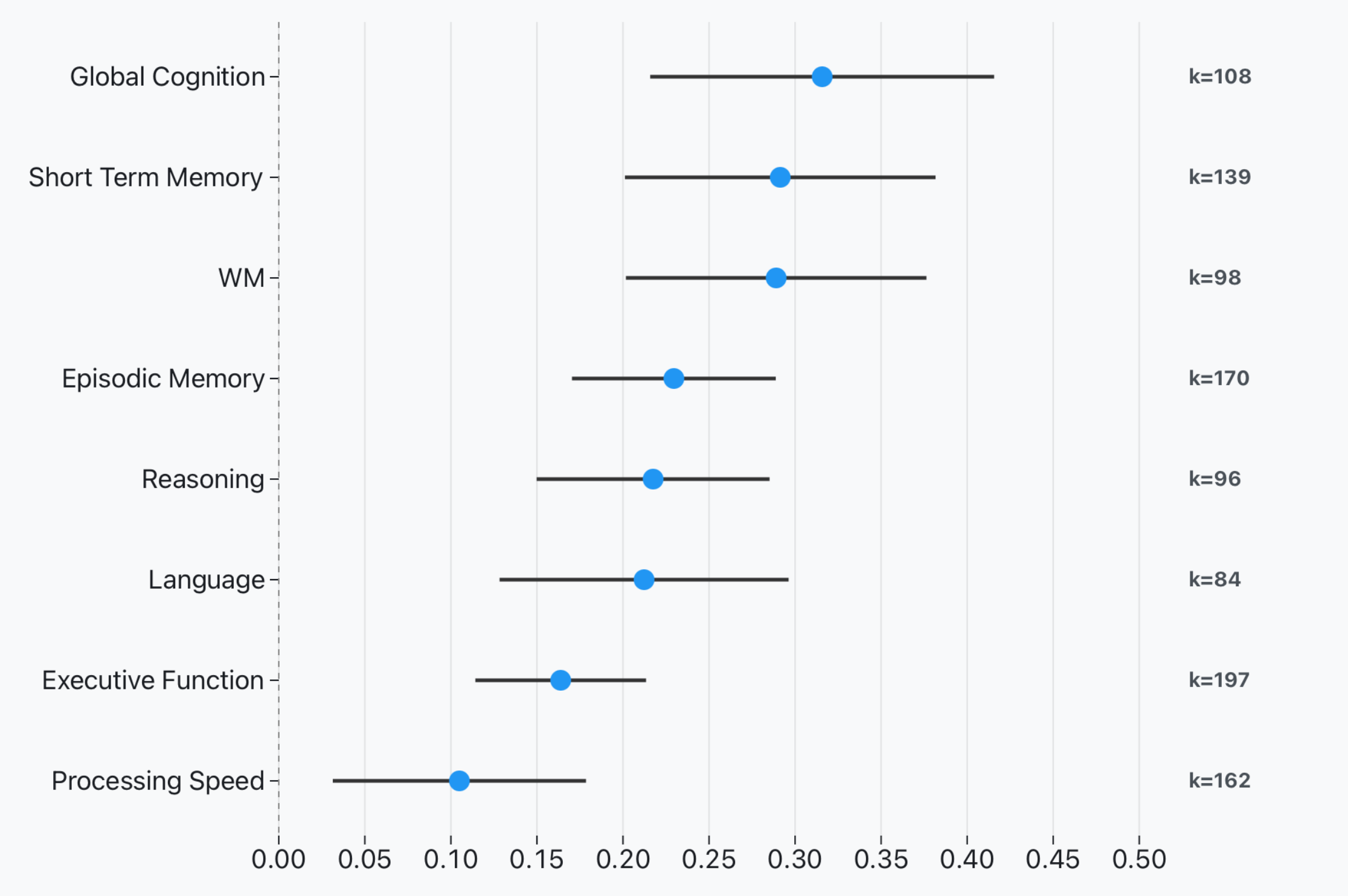
Cognitive Training: Showed similar efficacy in both Healthy Aging (0.29) and MCI (0.25).

Physical Exercise: Showed numerically larger effect in MCI (0.44) than Healthy Aging (0.23).

DIFFERENTIAL IMPACT BY COGNITIVE CONSTRUCT

Efficacy varies significantly across cognitive domains ($p<0.001$, $k=1054$). Stratified pooled effect sizes (SMD) revealed:

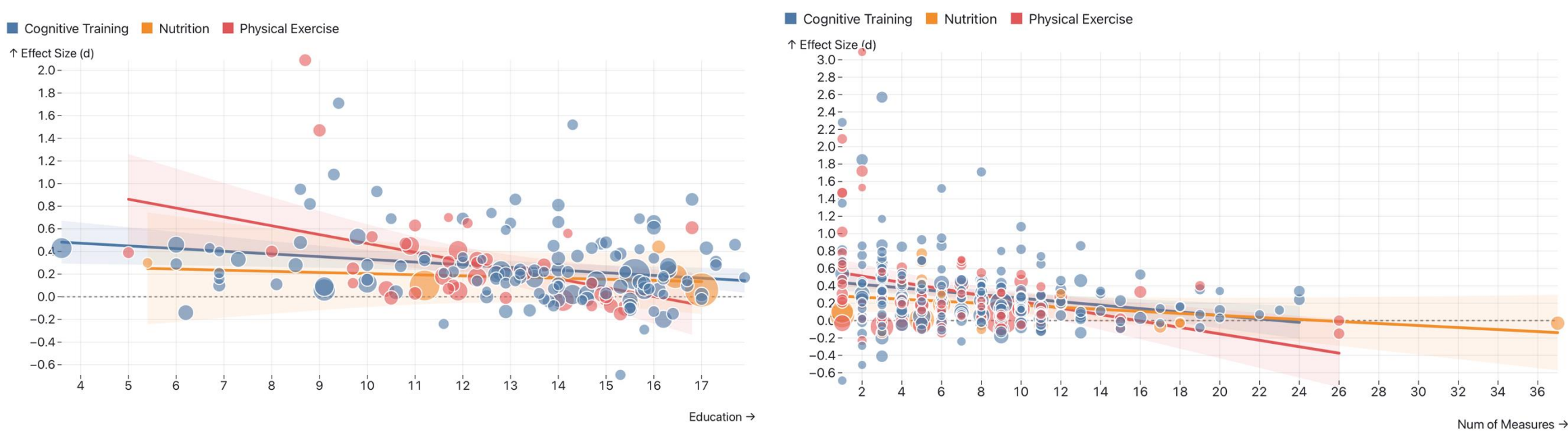
Most Gains: Global Cognition (e.g., MMSE or MoCA, 0.32), Short-Term Memory (0.31), & Working Memory (0.29).
Moderate Gains: Episodic Memory (0.23), Reasoning (0.22) & Language (0.22).
Lower Gains: Executive Function (0.16) & Processing Speed (0.11).



MODERATOR ANALYSIS

Meta-regressions identified Education and Number of Assessment Measures as critical, negative predictors of efficacy:

Education: Significant negative moderator for CT ($p=0.017$) and PE ($p=0.0086$). Explains 31% of exercise variance; interventions are most potent for individuals with lower baseline education.
Number of Assessment Measures: Total Number of study measures is a significant negative moderator ($p=0.0067$). Studies with more assessment measures may show lower effect sizes due to the inclusion of more off-target exploratory assessment measures



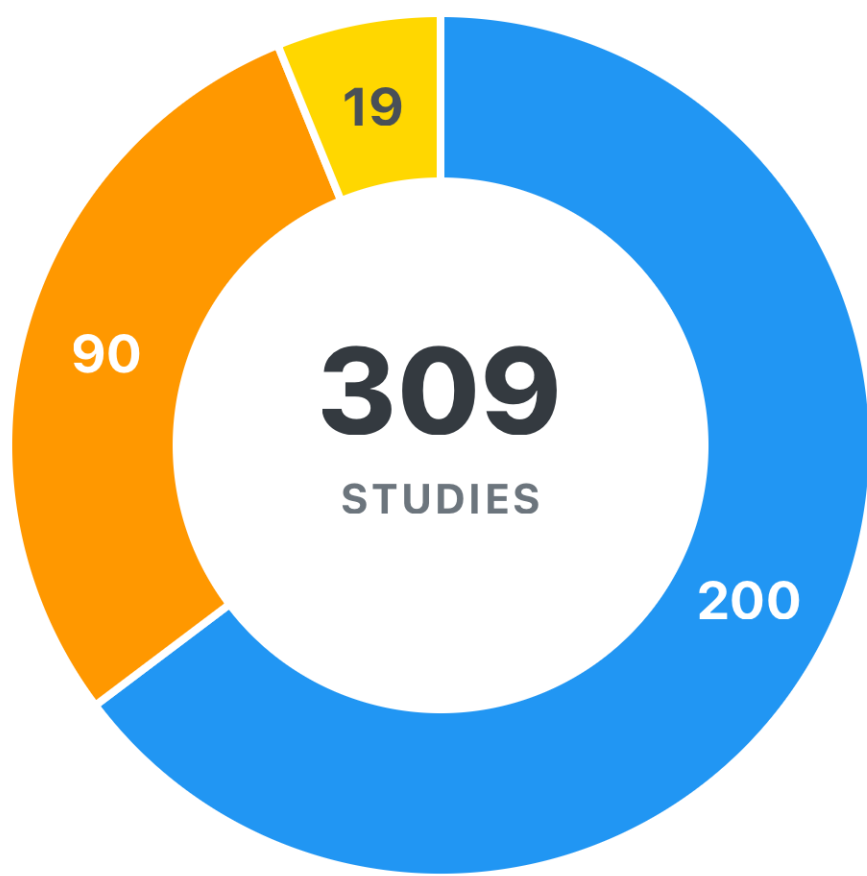
DISCUSSION

Better Cognitive Health: All three intervention classes showed statistically significant benefits to cognitive function, showing that behavioral interventions have an important role in health care for older adults.

Trial Design: PE efficacy was significantly moderated by control choice, with effects nearly doubling when compared against passive groups versus active ones. In contrast, CT maintained high therapeutic resilience regardless of control type.

Open-Source Analyses: The complete data set from included RCTs is available. We hope this data set will be of aid to future meta-analyses to avoid repetitive and error-prone raw data entry; and be of aid to policy-makers as they evaluate evidence for new clinical guidelines and health benefits.

INTERVENTION DISTRIBUTION & BASELINE CHARACTERISTICS



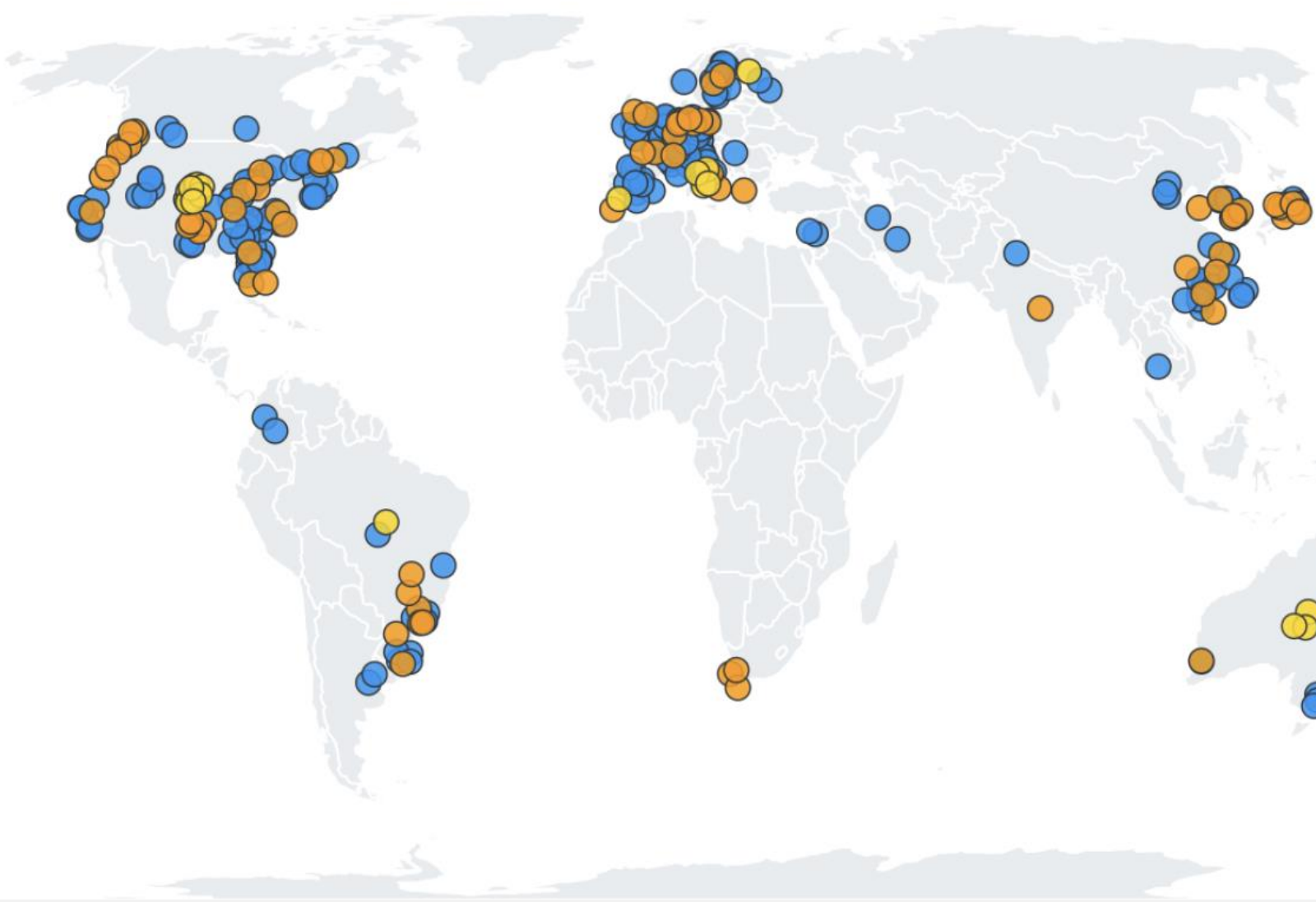
Cognitive Training	N = 11,347
AGE	70.8 ± 4.8
% FEMALE	62.1% ± 14.9%
EDUCATION	13.2 ± 3.1
MEASURES	7.8 ± 5.0
TOTAL WEEKS	8.2 ± 10.9

Physical Exercise	N = 7,313
AGE	71.3 ± 5.8
% FEMALE	69.1% ± 18.7%
EDUCATION	12.1 ± 2.4
MEASURES	6.8 ± 5.0
TOTAL WEEKS	21.6 ± 15.1

Nutrition	N = 2,938
AGE	67.8 ± 4.6
% FEMALE	57.8% ± 7.9%
EDUCATION	13.6 ± 4.5
MEASURES	9.4 ± 8.6
TOTAL WEEKS	40.7 ± 55.8

GLOBAL DISTRIBUTION OF CLINICAL TRIALS

■ Cognitive Training ■ Physical Exercise ■ Nutrition



Lifestyle intervention trials are concentrated in the Global North. Geography tends to be confounded with education, with East Asian studies generally including participants with lower education.